

AFML-TR-78-64

ADA070669

OFFICIAL FILE COPY

THERMOGRAVIMETRIC ANALYSIS OF POLYMERS IN AIR

Polymer Branch
Nonmetallic Materials Division

August 1978

TECHNICAL REPORT AFML-TR-78-64

Final Report for Period November 1977 through February 1978

Approved for public release; distribution unlimited.

AIR FORCE MATERIALS LABORATORY
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

20040225031

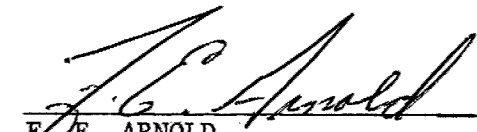
BEST AVAILABLE COPY


NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

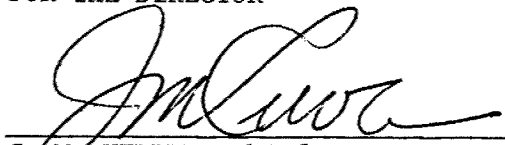
This report has been reviewed by the Information Office (ASD/OIP) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.


E. E. ARNOLD
Project Scientist


R. L. VAN DEUSEN, Chief
Polymer Branch
Nonmetallic Materials Division

FOR THE DIRECTOR


J. M. KELBLE, Chief
Nonmetallic Materials Division

"If your address has changed, if you wish to be removed from our mailing list, or if the addressee is no longer employed by your organization please notify AFML/MBP, W-PAFB, OH 45433 to help us maintain a current mailing list".

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFML-TR-78-64	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) THERMOGRAVIMETRIC ANALYSIS OF POLYMERS IN AIR		5. TYPE OF REPORT & PERIOD COVERED Final Report November 1977 - February 1978
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Gerhard F. L. Ehlers, AFML/MBP Edward J. Soloski, UDRI		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Air Force Materials Laboratory (AFML/MBP) Air Force Systems Command Wright-Patterson Air Force Base, OH 45433		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62102F/2419/04 24190415
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Materials Laboratory (AFML/MBP) Air Force Systems Command Wright-Patterson Air Force Base, OH 45433		12. REPORT DATE August 1978
		13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release, distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Thermogravimetric Analysis Polymers		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report is concerned with the weight loss curves of 107 polymers, representative of a wide range of systems such as aliphatic, fluoroaliphatic, aromatic, heterocyclic and semiorganic, are presented. The data have been obtained in a DuPont 951 Thermogravimetric Analyzer in air at a heating rate of 20°C/min.		

FOREWORD

This report was prepared by the Polymer Branch, Nonmetallic Materials Division. The work was initiated under WUD #43, "Structural Resins". It was administered under the direction of the Air Force Materials Laboratory, Air Force Wright Aeronautical Laboratories, Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, with Dr. G. F. L. Ehlers (AFML/MBP) as Project Scientist.

The report covers work conducted from November 1977 to February 1978 by G. F. L. Ehlers, Air Force Materials Laboratory and E. J. Soloski, University of Dayton Research Institute. It was submitted for publication by the authors in February 1978.

TABLE OF CONTENTS

SECTION		PAGE
I	INTRODUCTION	1
II	DISCUSSION	2
III	RESULTS	3

LIST OF TGA CURVES

	PAGES
Aliphatic (addition type) polymers	4-13
Fluoroaliphatics	14-21
Delrin	22
Nylon 6,6	23
Epoxy resins	24-27
Phenolic resin	28
Pyrolyzed rayon	29
Polyphenylenes	30-33
Polyphenylene oxides	34-40
Polyphenylene sulfones	39-42
Polyphenylene sulfoxide	43
Polyphenylene sulfide	44
Aromatic polyesters	45-48
Polycarbonate	49
Polyxylylenes	50-51
Polyurea	52
Aromatic polyamides	53-56
Polyimides	57-60
Polybenzimidazoles	61-69
Polybenzoxazoles	70-77
Polyoxadiazoles	78-80
Polybenzothiazoles	81-83
Polythiadiazoles	84
Polyquinoxalines	85-94
BBB and related structures	95-98
Miscellaneous polyheterocyclics	99-104
Silicon containing polymers	105-110

SECTION I

INTRODUCTION

Between 1960 and 1977, thermal analysis data have been determined on approximately 1800 experimental polymers, prepolymers, and oligomers. The majority of these data consisted of weight loss studies under programmed and isothermal conditions, and DTA and DSC scans. Some samples have been subjected to thermomechanical analysis, torsion braid analysis, and thermal decomposition/mass spectrographic analysis.

As far as thermogravimetric data under programmed conditions are concerned, the predominant number of samples have been run on a modified Chevenard Thermobalance at a fixed heating rate of approximately $3^{\circ}\text{C}/\text{min}$, and in most cases in a nitrogen atmosphere. These data served for many years to obtain a quick and first indication about the basic thermal stability of a polymer system.

However, more recently, these methods and results became inadequate. The Chevenard balance required relatively large sample sizes (50 - 100 mg). The fixed heating rate of $3^{\circ}\text{C}/\text{min}$ allowed only one run per day, and the results could not be compared to DSC or TMA runs on the same polymer; here, heating rates of $20^{\circ}\text{C}/\text{min}$ are being used in order to obtain optimal sensitivity and resolution for the detection of glass transition temperatures. Furthermore, increased need for weight loss data in air required additional data.

SECTION II

DISCUSSION

107 polymer samples, representative of systems such as aliphatic, fluoroaliphatic, aromatic, heterocyclic and semiorganic structures, were subjected to programmed thermogravimetric analysis in the Dupont 951 Thermogravimetric Analyzer. A heating rate of 20°C/min was used, and the scans were carried out in an air atmosphere with a flow rate of 72 cc/min.

A number of the weight loss plots showed irregularities of the type seen on pages 79, 90, 91, 99, and 101. Vigorous gas evolution at this fast heating rate cools sample and thermocouple, resulting in a shift of the weight loss curve towards lower temperatures. These irregularities normally have been eliminated during replotting, with the exception of the cases on the above pages. An extreme case was Delrin, which had about a 70°C drop in temperature beyond the last point of the curve shown on page 21. It was impossible in this case to correct the curve.

AFML-TR-78-64

SECTION III

RESULTS

